DOCUMENT RESUME

ED 319 593 SE 051 403

AUTHOR Horn, Laura
TITLE Trends in High School Math and Science Course Taking: Effects of Gender and Ethnicity.
PUB DATE 90
NOTE 32p.; Paper presented at the Annual Meeting of the American Educational Research Association (Boston, MA, April 16-20, 1990).
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS *Course Selection (Students); Educational Improvement; *Educational Trends; *Females; High Schools; Mathematics Curriculum; Mathematics Education; *Minority Groups; National Surveys; Science Curriculum; Science Education; *Secondary School Mathematics; *Secondary School Science

ABSTRACT

Improving the quality of primary and secondary education has become a national imperative, especially in the fields of mathematics and science. Many have cited the results of international comparisons as cause for alarm and thus for the need to make fundamental changes in the educational system. With so much attention focused on the need for better mathematics and science education, it is important to understand the changing patterns in course taking in these fields. The purpose of this paper is to provide a descriptive summary of the changing trends in high school course taking in mathematics and science for students who graduated between 1969 and 1987. This analysis focuses specifically on gender and racial/ethnic group differences. The study compares the average number of credits completed in mathematics and science classes for public school students based on high school transcripts collected in four national surveys. These surveys included the Educational Testing Service Study of Academic Prediction and Growth (1969); the National Longitudinal Survey of Labor Force Experience: Youth Cohort (1975-1978 and 1979-1982); High School and Beyond (1982); and the National Assessment of Educational Progress Transcript Study (1987). Twenty-eight figures display the statistical data. (CW)

Laura Horn

TRENDS IN HIGH SCHOOL MATH AND SCIENCE COURSE TAKING: EFFECTS OF GENDER AND ETHNICITY

MPR Associates, Inc.
1995 University Avenue, Suite 225
Berkeley, CA 94704
(415) 849-4942

A paper prepared for the annual meeting of the American Educational Research Association
Boston, April 16, 1990

This paper is based, in part, on research conducted for the National Assessment of Vocational Education, Department of Education. The views expressed are the author's and are not necessarily those of the Department of Education.

Introduction

Improving the quality of primary and secondary education has become a national imperative, especially in the fields of math and science. The poor performance of American youth on math achievement tests, particularly compared to their European and Japanese counterparts, is frequently cited as cause for alarm and thus for the need to make fundamental changes in the educational system (National Science Board, *Science and Engineering Indicators*, 1987). In response to this need, many states have increased high school graduation requirements, emphasizing greater student participation in core subjects such as math, science, English, and foreign languages (Clearing House Notes, 1987). Of particular concern to educators in their effort to improve basic education is increasing participation in math and science by those traditionally underrepresented in the fields: women and minorities. Recently a federally sponsored task force was formed to address this need. Their primary goal is "that all children born today, from all backgrounds, have a quality education, including mathematics and science education, and the opportunity to participate in the science and engineering workforce to their fullest potential" (Task Force on Women, Minorities, and the Handicapped in Science and Technology, 1989). With so much attention being focused on the need for better math and science education, it is important to understand the changing patterns in course taking in these fields, particularly in response to recently enacted education reforms.

The objective of this paper is to provide a descriptive summary of the changing trends in high school course taking in math and science for students who graduated between 1969 and 1987. This analysis focuses specifically on gender and racial/ethnic group differences.

Methods

This study compares the average number of credits completed in math and science classes for public high school students who graduated between 1969 and 1987. High school transcripts collected in four national surveys were used to make the comparisons. These national surveys included the Educational Testing Service Study of Academic Prediction and Growth (1969); the National Longitudinal Survey of Labor Force Experience: Youth Cohort (1975-1978 and 1979-1982); High School and Beyond (1982); and the National Assessment of Educational Progress Transcript Study (1987) (see Tuma et al, 1988 for a detailed account of sample selection and analytic methods used in this study).

Samples

The number of students from each survey incorporated into this study included:

- Educational Testing Service's Study of Academic Prediction and Growth (ETS 1969) N = 5,637
- National Longitudinal Survey of Labor Force Experience: Youth Cohort (NLSY 1975-1978 and 1979-1982) N = 8,308
- High School and Beyond Transcript Study (HS&B 1982) N=1[illegible]5
- National Assessment of Educational Progress High School Transcript study (NAEP 1987) N = 24,47[illegible]

The HS&B and NAEP cohorts were highly stratified, clustered samples and were designed to be nationally representative.[1] Each student in both samples had an associated weight that represented the probability of being selected from the national population. Additional weighting procedures were applied to the samples to take into account non-response to the surveys.

The ETS cohort was not originally designed to be nationally representative. However, it included 24 schools in 17 communities selected to vary by geographic area, school system size, and the proportion of students continuing on to higher education. Other work with the ETS sample has shown it to be approximately representative of public high school graduates in 1960 (Hilton, 1979).

The NLSY cohort consisted of a 1979 base year survey of 14- to 24-year-olds. Transcripts, however, were collected only from respondents who agreed to supply them and graduation dates ranged from 1971 to 1984. For the purpose of this analysis, we restricted our inquiry to the years with the greatest number of graduates: 1975 through 1982. To reduce potential bias in this sample, we developed an algorithm of re-weighting procedures that adjusted for known nonresponse.

One problem of comparison between the NLSY cohort and the others is that the racial/ethnic groups in the NLSY cohort were divided into black students, Hispanic

[1] Unlike the ETS and NLSY cohorts, HS&B and NAEP surveyed a sample of the Native American high school population. However, the numbers surveyed were very small, and the response rates were low, making the accuracy of predictions about this population questionable. Therefore, rather than attempt to make generalizations that may be unreliable, we chose not to include Native Americans in this study.

students, and "other," a category largely consisting of white students. Thus, estimates of the number of credits completed by Asian students in this cohort were impossible to make.[2]

Sample selection rules were applied to each data set to ensure that the data were as representative as possible of American high school graduates. Three basic rules were used for inclusion in the sample: 1) graduation from high school; 2) completion of 16 to 32 course credits;[3] and 3) completion of at least some English (> 0 credits) over four years of high school.

Course comparability

To ensure comparability across data sets, a taxonomy of secondary courses, developed as part of a research project for the National Assessment of Vocational Education, was applied to each transcript file (Hoachlander et al, 1989). The Secondary School Taxonomy (SST) organizes the high school courses into three curricula: academic, vocational, and personal/other. The SST further divides each curriculum into subjects (e.g. English, mathematics, science, etc.) and then into specific courses within each subject. For example, math is divided into courses such as general or basic math, algebra, geometry, calculus, and other advanced courses.

Estimates and statistical procedures

It is important to remember that the surveys used in this study were designed for different purposes and, therefore, are inherently different from one another. As a result, we limited comparisons among cohorts to mean estimates of the average number of credits completed. Changes in the number of credits largely reflected changes in students' overall participation.

Due to the complexity of the sample design, standard errors could not be calculated using simple statistical procedures. We therefore applied a statistical application using the Taylor series approximation techniques for estimating the variance of complex samples.[4]

---

[2] In all the figures, the NLSY group designated as "white" is made up of this "other" category.

[3] A credit is defined as one Carnegie unit and is approximately equivalent to one class meeting 5 days a week for a school year.

[4] The variance estimation procedure applied to the data was a SAS procedure called CDCTAB developed by C. Dennis Carroll at the National Center for Education Statistics.

When differences between groups or "significance" are mentioned, they were determined using a Student 's t test ($p<0.05$) for paired comparisons. These comparisons are intended to present a *general* idea of how course taking may have changed between 1969 and 1987.

Results

On average, students in 1969 earned a relatively high number of credits in math and science. The rate of course taking declined in the cohorts between 1975 and 1982. After 1982, however, the rate of course taking increased dramatically. The 1987 cohort earned more credits in math and science than any previous cohort. The increase in the number of credits earned between 1982 and 1987 was seen for all types of students, regardless of gender or race/ethnicity.

Young women made considerable gains in math and science course taking (Figures 1 and 2). For example, in 1969 young men took, on average, one semester more of math than young women (2.73 credits compared to 2.23 credits) and approximately one-half semester more of science (2.38 credits compared to 2.10 credits). However, in the intervening cohorts between 1975 and 1982, there was little to no decline in the number of credits earned by young women, whereas the number of credits earned by young men significantly decreased. By 1987, young women earned virtually the same number of credits in science (a difference of 0.04 credits), and earned 0.09 credits less in math (a small, but still significant difference) than young men. Even more encouraging for young women is fact that the convergence in the number of credits earned between young men and women in the math curriculum occurred in the more advanced subjects.

All racial/ethnic groups made significant gains in total credits completed in math and science between 1969 and 1987 (Figures 3 and 4). This was particularly apparent between 1982 and 1987. For example, Hispanic students had an especially notable increase in the number of math credits earned: a change of more than one semester (2.24 credits compared to 2.86 credits) between 1982 and 1987. No other racial/ethnic group had as large an increase in the number of credits earned in either science or math.

Asian students consistently earned more total credits in math and science than any other racial/ethnic group, and this difference appeared to increase over time. For example, Asian students earned approximately 0.40 more math credits than white students in 1969,

Figure 1-- Average number of math credits earned by male and female high school students by year of graduation

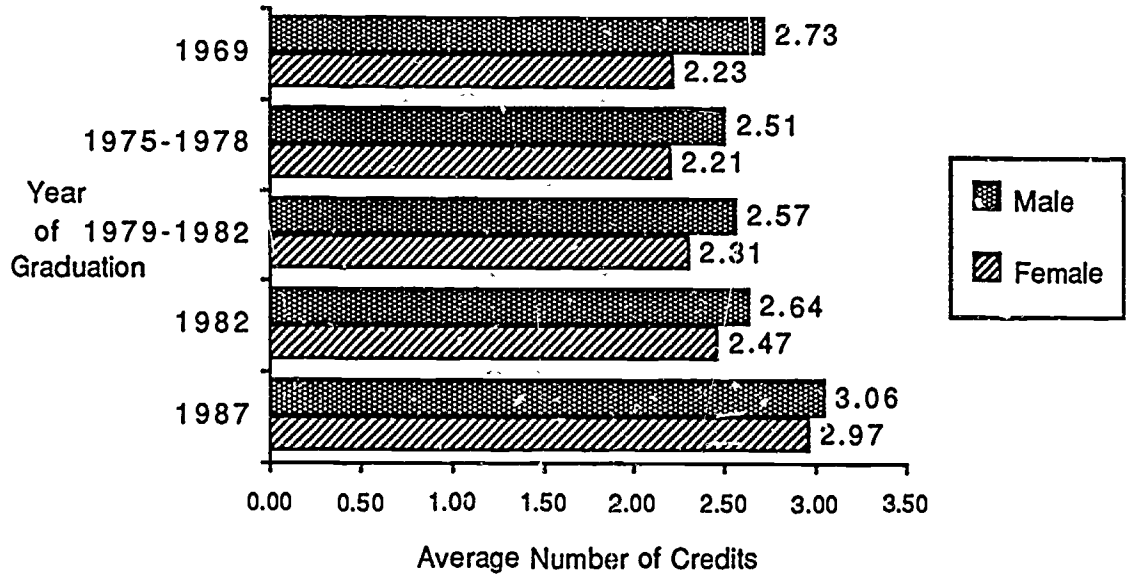


Figure 2 -- Average number of science credits earned by male and female high school students by year of graduation

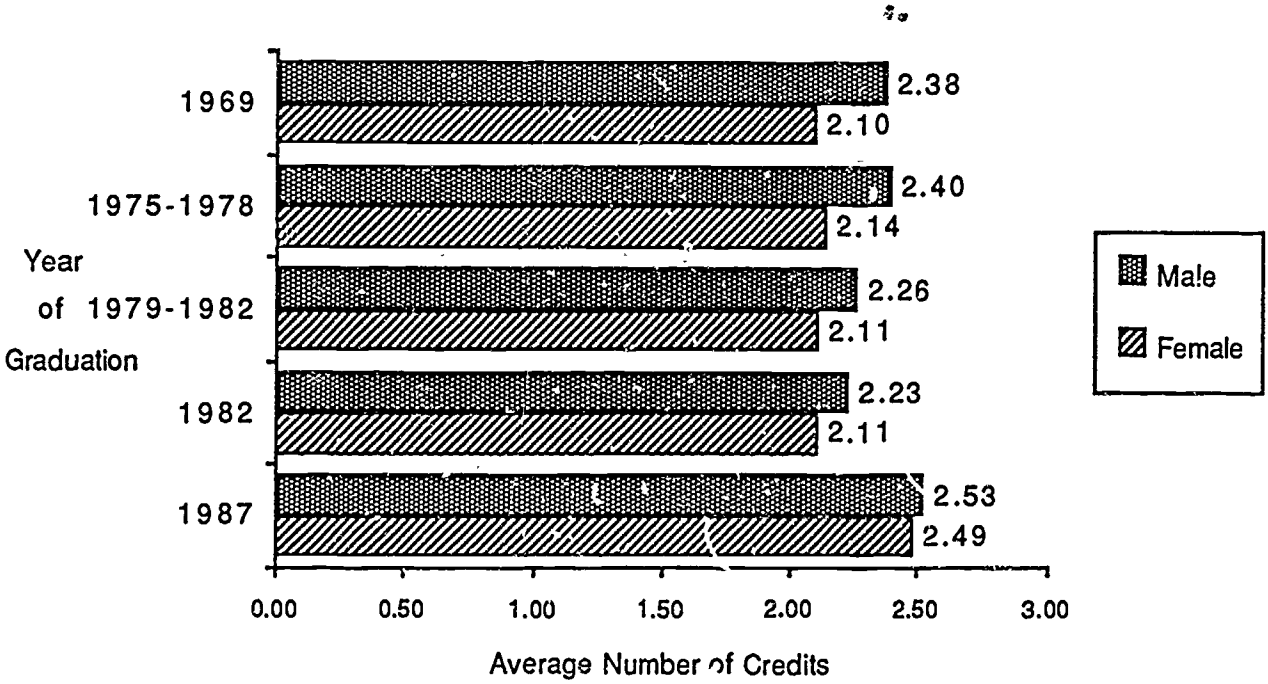


Figure 3 -- Average number of math credits earned by different racial/ethnic groups

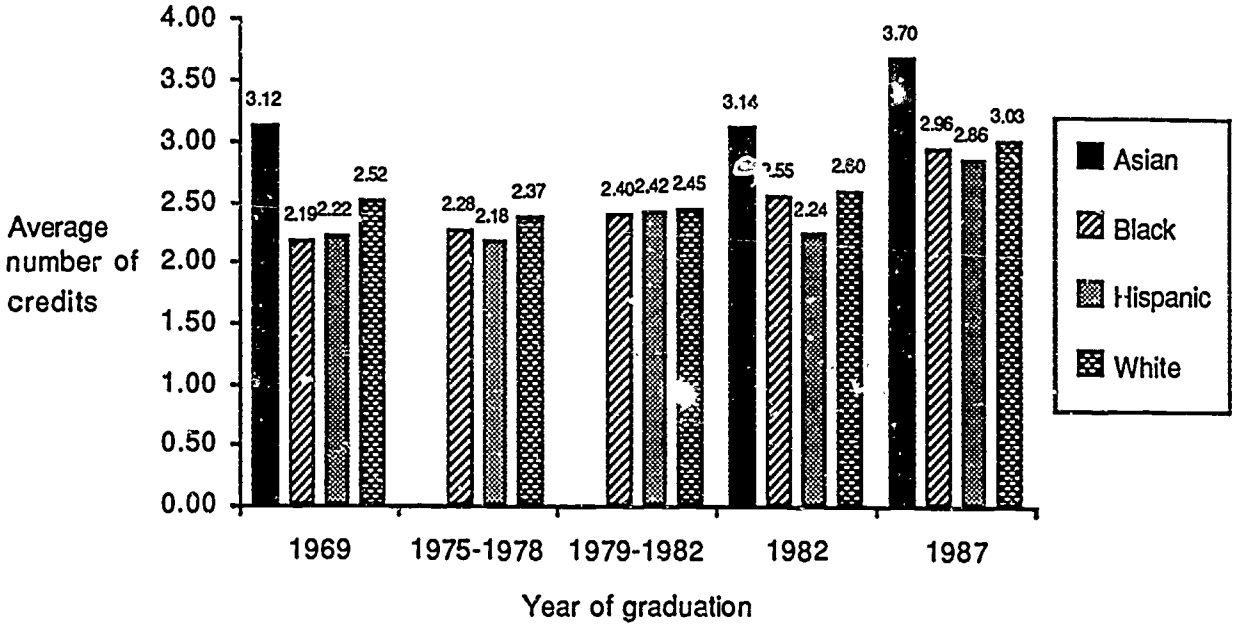
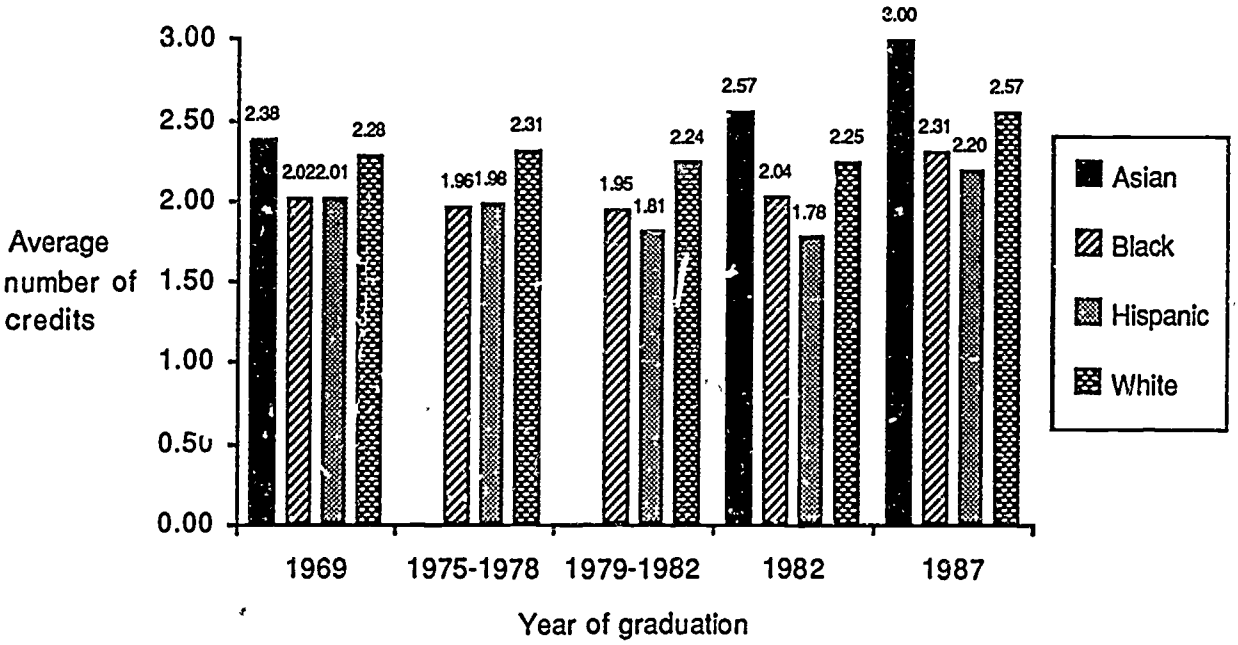


Figure 4 -- Average number of science credits earned by different racial/ethnic groups



followed by a difference of 0.46 credits in 1982. Finally Asian students earned 0.67 more math credits (more than one semester of math) than white students in 1987.

Even though gains were made in the total number of math and science credits earned by all students, the level and complexity of classes taken often differed according to gender and race/ethnicity. The following section details the specific subjects taken by the various subgroups of students.

Math

The math curriculum was divided up into eight areas that reflected both specific subjects and also the level of the class:

- Basic math -- primarily remedial
- General math -- 7th and 8th grade math
- Applied math -- technical math including computer and information sciences and mathematics for employment
- Pre-algebra
- Algebra I
- Geometry
- Advanced (other than calculus) -- Algebra II and III, trigonometry, math analysis, statistics
- Calculus -- analytic geometry and calculus, advanced placement/honors

Basic and general math

Basic and general math reflected opposing patterns of credits earned over the different years of graduation. The number of credits earned in basic math declined significantly between the 1969 and 1975-1978 cohorts. During the same period of time the number of credits earned in general math increased significantly. This may have represented a trend toward aggregating "below level" math classes into the general category. After 1969 and between 1975 and 1982, the number of credits earned did not change significantly for either basic or general math. In 1987, however, the number of credits earned in basic math increased slightly, while those earned in general math decreased.

In almost every cohort, young men earned slightly more credits than young women in basic and general math (Figures 4 and 5). Even though the differences were not statistically significant in any one cohort, they tended to be very consistent.

Figure 5 -- Average number of credits earned in basic math

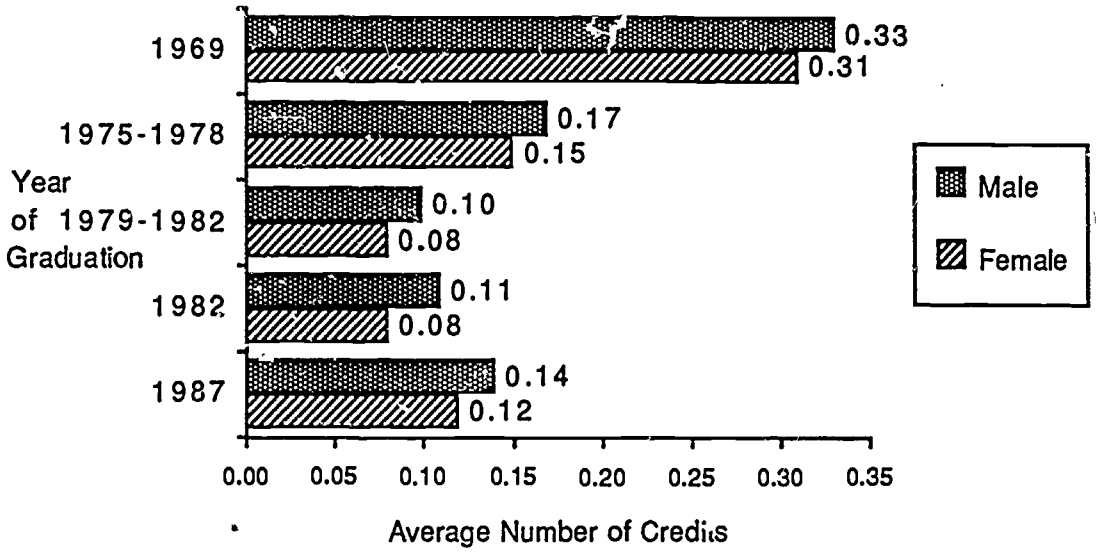
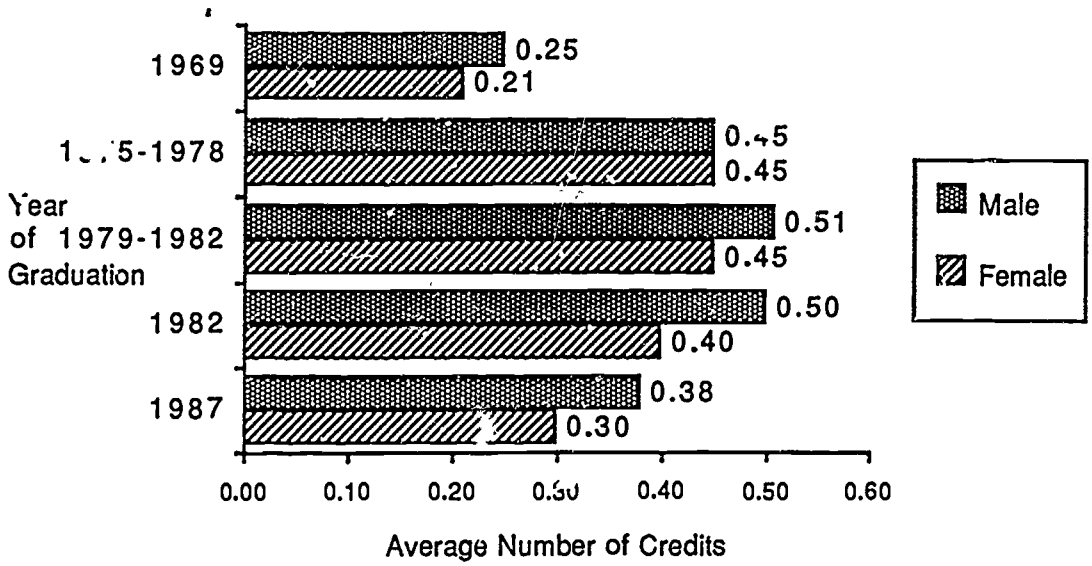


Figure 6 -- Average number of credits earned in general math



In 1969, 1982, and 1987 Hispanic and black students earned more credits in basic math than either Asian or white students (Figures 7 and 8). In all cohorts except 1969, black students earned the most credits in general math. Between 1982 and 1987, both Hispanic and black students showed an increase in the number of credits earned in basic math and a decrease in credits earned in general math.

Figure 7 -- Average number of credits earned in basic math

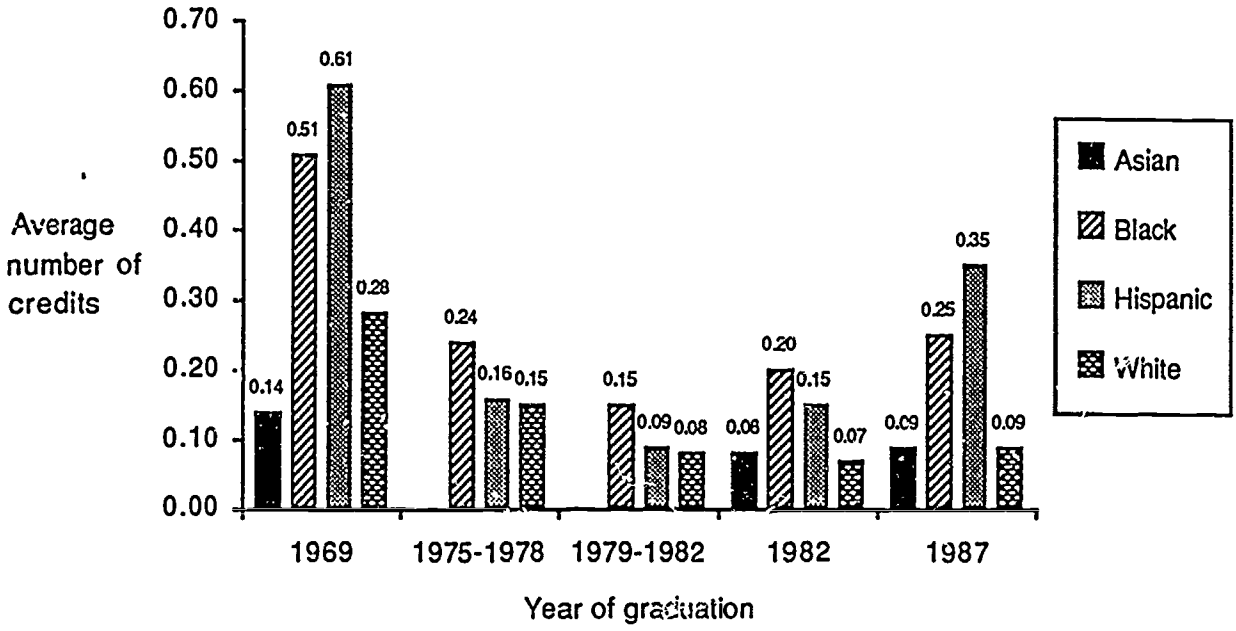
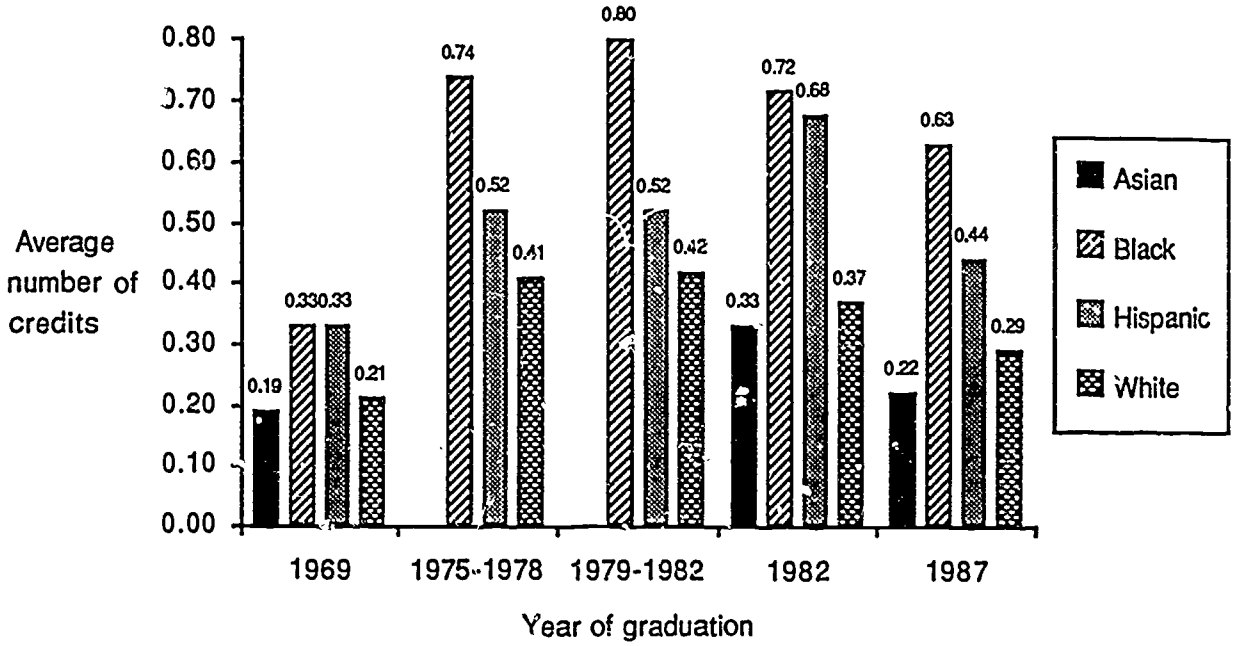


Figure 8 -- Average number of credits earned in general math



Applied math

Applied math is a subject that has changed in scope due to the increased use of computers over the last decade. Between 1969 and 1982, there was a small but consistent increase in the number of credits earned in applied math, with a significant jump in credits earned by all students, regardless of gender or race/ethnicity, between 1982 and 1987.

Very few students earned credits in applied math in 1969, and those that did were primarily males (Figure 9). In all cohorts, young men earned slightly more credits than young women in this field. Both young men and women demonstrated significant increases in the number of credits earned between 1982 and 1987.

Figure 9 -- Average number of credits earned in applied math

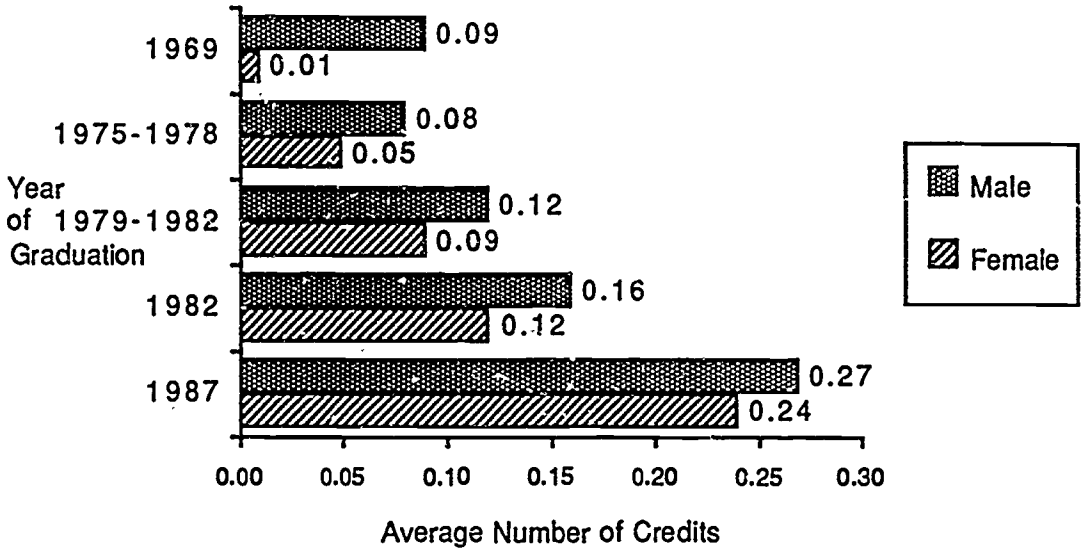
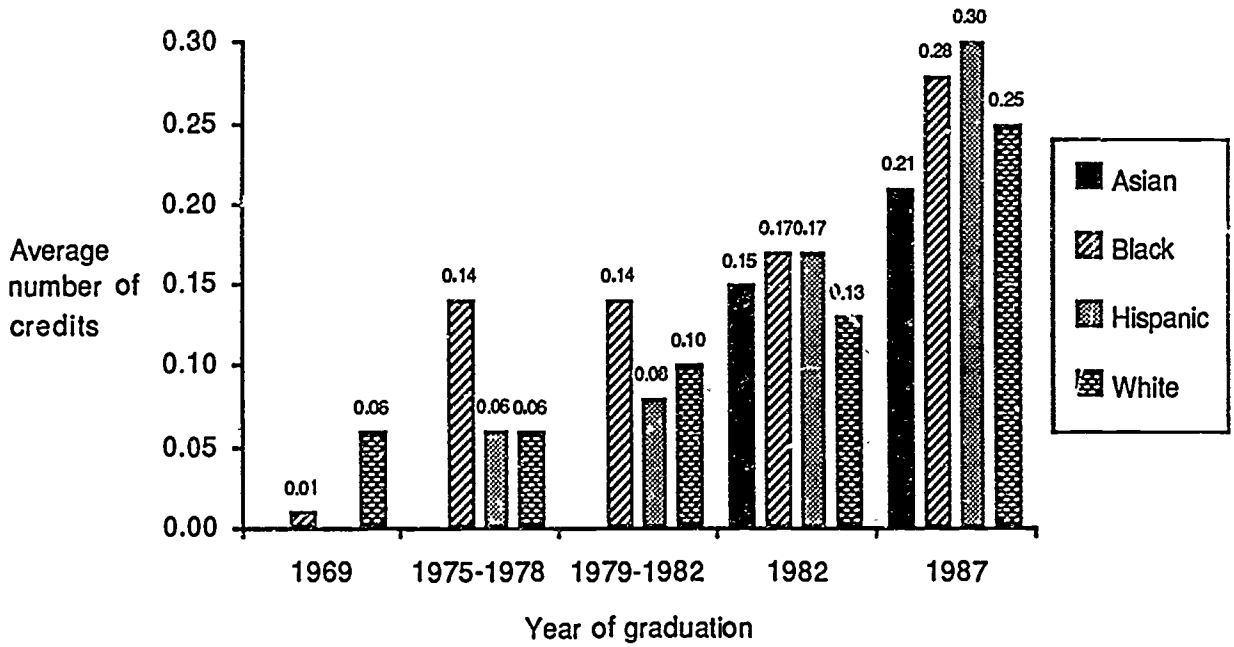


Figure 10 -- Average number of credits earned in applied math*



* Hispanic and Asian students earned < 0.01 credits in 1969

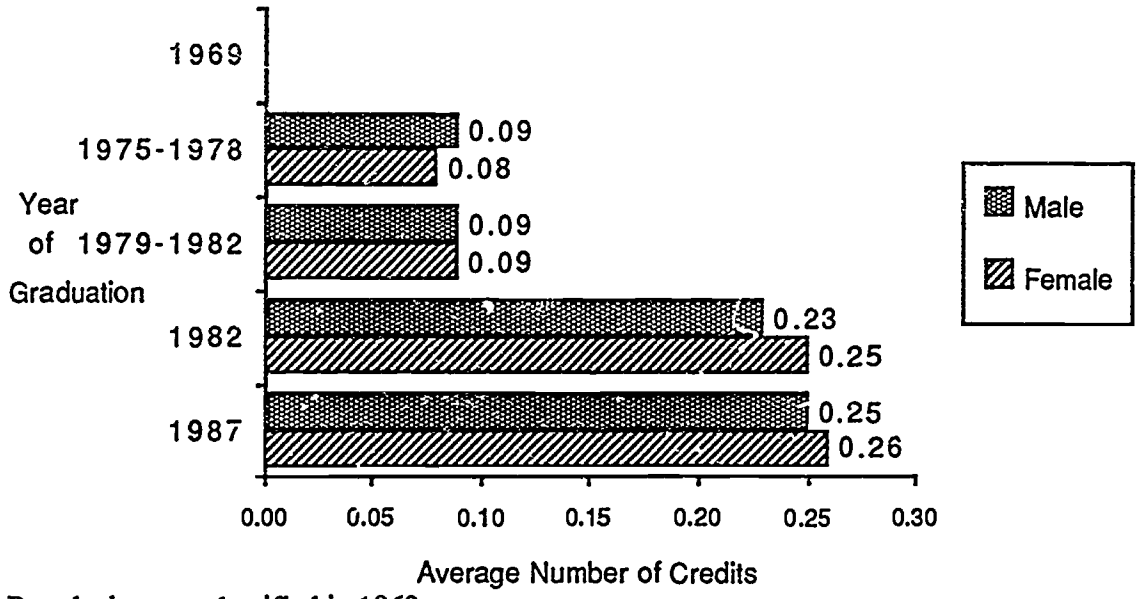
In the NLSY cohorts between 1975 and 1982, black students tended to earn more credits than either Hispanic or white students in applied math (Figure 10). However, in the

HS&B cohort, all racial/ethnic groups, including Asian students, earned similar numbers of credits: the lowest was 0.13 credits earned by white students compared to the highest of 0.17 credits earned by both black and Hispanic students. Between 1982 and 1987, black, Hispanic, and white students had a significant increase in the number of credits earned in applied math. This increase was especially noticeable for Hispanic students, who more than doubled the number of credits they earned.

Pre-algebra

Pre-algebra was a subject not classified in 1969 and very few credits were earned in this subject in the NLSY cohort between 1975 and 1982.[5] In the HS&B 1982 cohort, however, the number of credits earned was more than double the number earned in the NLSY cohorts. In all years from 1975 to 1987, young men and women earned approximately the same number of credits (Figure 11).

Figure 11 -- Average number of credits earned in pre-algebra*



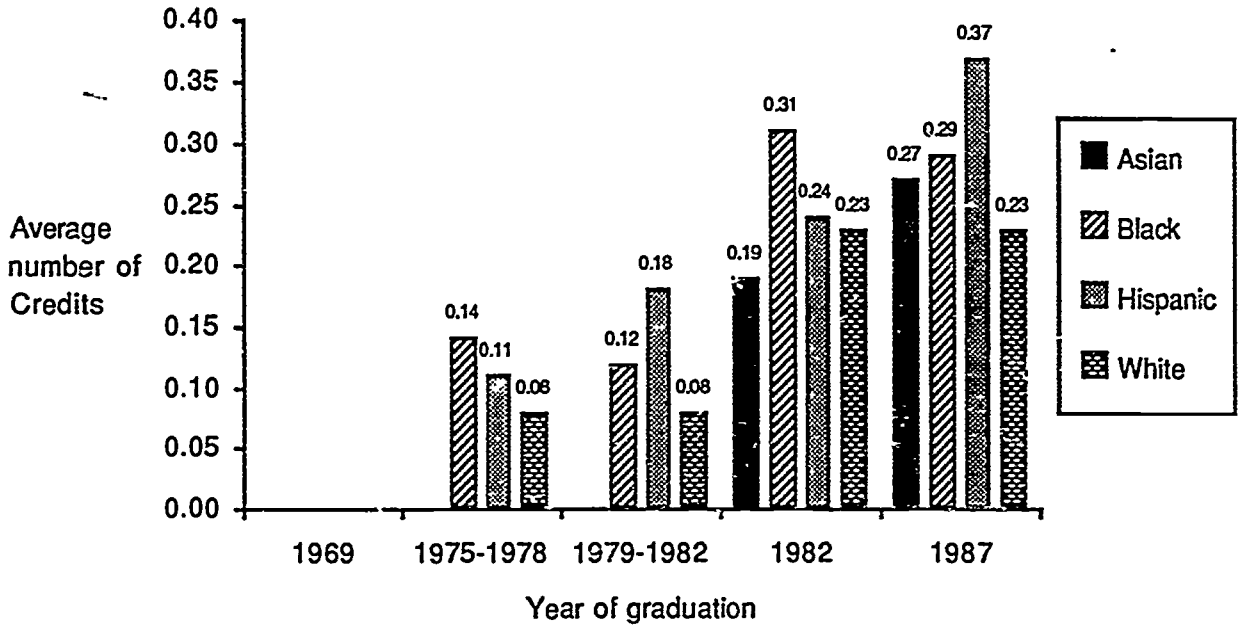
* Pre-algebra not classified in 1969

Hispanic students showed the most notable and consistent change in credits earned in pre-algebra over all cohorts: increasing from 0.11 credits earned in the 1975-1978 cohort to

[5]Pre-algebra may have been classified as general math or as algebra.

0.18 credits in 1979-1982, climbing to 0.24 credits in 1982, and rising to 0.37 credits earned in 1987 (Figure 12). Hispanic students earned significantly more credits in pre-algebra in 1987 than any other racial/ethnic group.

Figure 12 -- Average number of credits earned in pre-algebra*



* Pre-algebra not classified in 1969

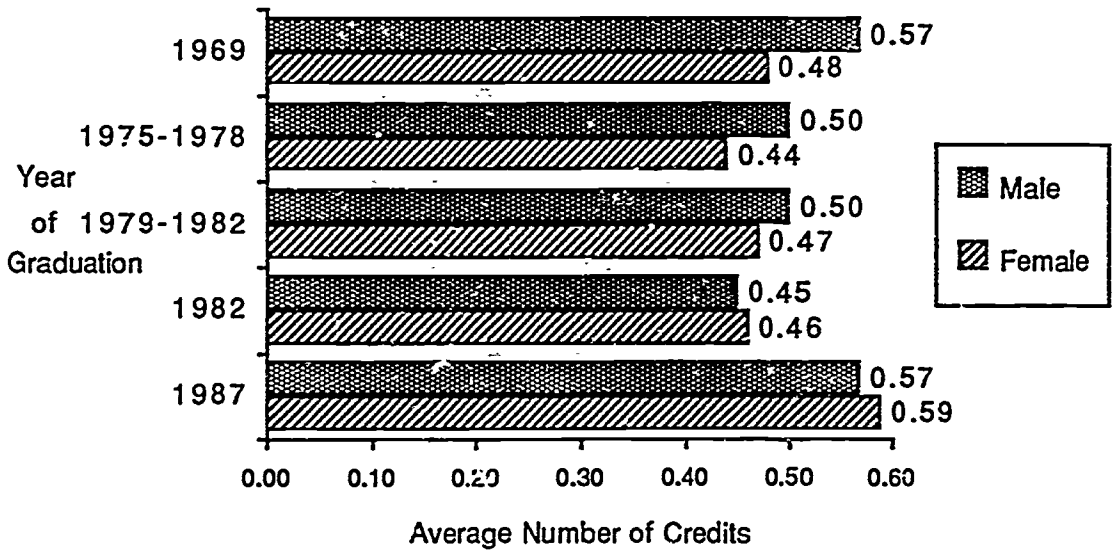
Black students also experienced an appreciable increase in the number of credits earned in pre-algebra, from 0.12 to 0.31 credits in the intervening years between 1975 and 1982. However, there was little change in the number of credits black students earned in pre-algebra between 1982 and 1987.

White students earned the same number of credits in pre-algebra in 1982 and 1987, after an increase from 0.08 to 0.23 credits between the 1979-1982 NLSY cohort and the 1982 HS&B cohort. Asian students, who appear as a separate racial/ethnic group only in 1982 and 1987 increased the number of credits they earned from 0.19 to 0.27 credits.

Geometry

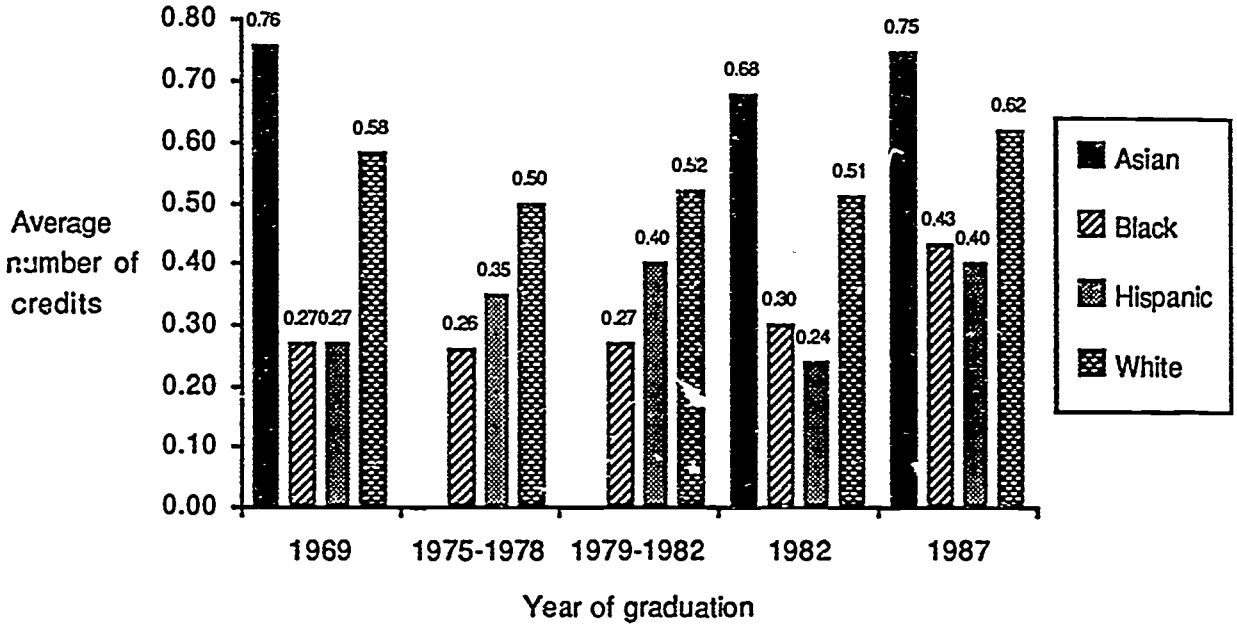
There was very little variation in the number of credits earned by all students in geometry between 1969 and the NLSY 1979-1982 cohort. However, during these years, young women gradually approached young men in the number of credits earned. In 1982 and 1987 young men and women earned virtually the same number of credits (Figure 13).

Figure 13 -- Average number of credits earned in geometry



Between 1982 and 1987, all students with the exception of Asians, had a significant increase in the number of credits earned in geometry. Asian students consistently earned the most credits than any other racial/ethnic group (Figure 14). However, they showed the least amount of change in the number of credits earned over all the years (0.76 in 1979, 0.68 in 1982, and 0.75 in 1987).

Figure 14 -- Average number of credits earned in geometry



Algebra

Algebra is the only math subject in which the number of credits earned in 1969, regardless of gender and race/ethnicity, was greater than the number earned in 1987.[6] After a significant decline between the 1969 and the 1975-1978 cohorts, the number of credits earned held steady through 1982. Like most other math subjects, there was a surge of credits earned between 1982 and 1987. Young men and women earned roughly similar numbers of credits throughout all the cohorts (Figure 15).

[6]It is possible that pre-algebra was classified as algebra in the 1969 cohort.

Figure 15 -- Average number of credits earned in algebra

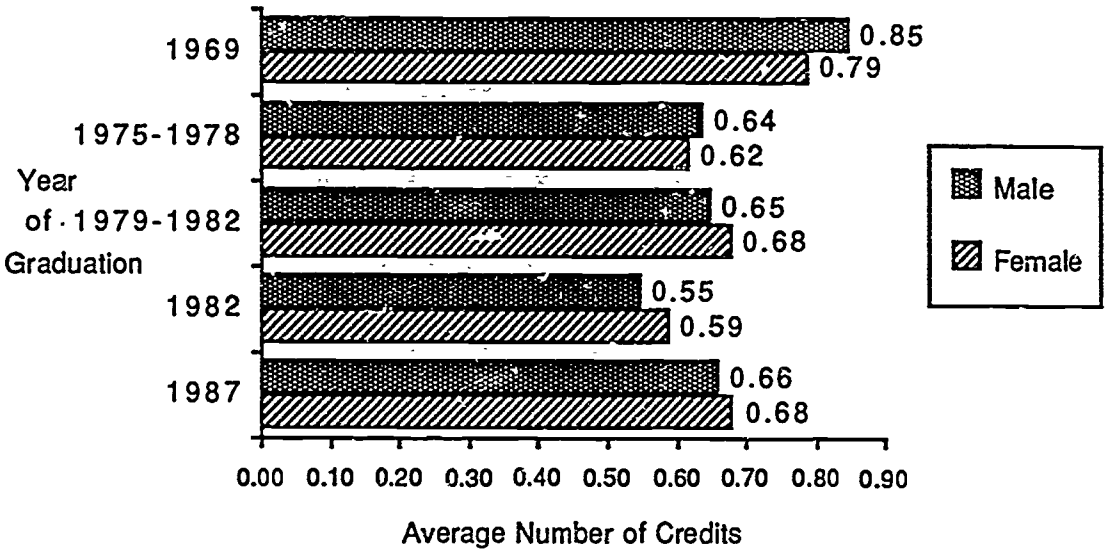
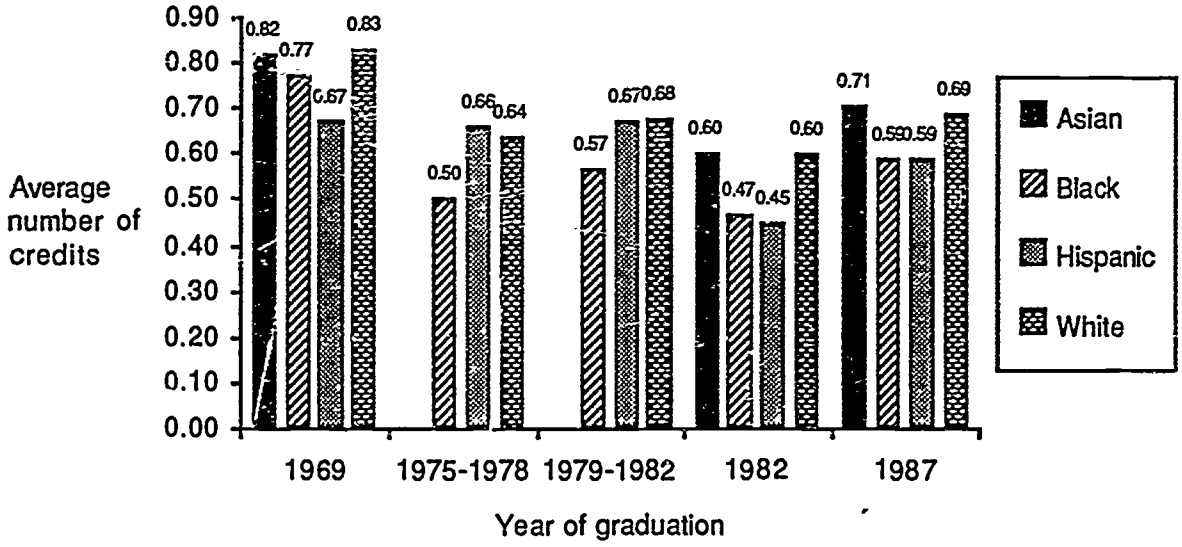


Figure 16 -- Average number of credits earned in algebra



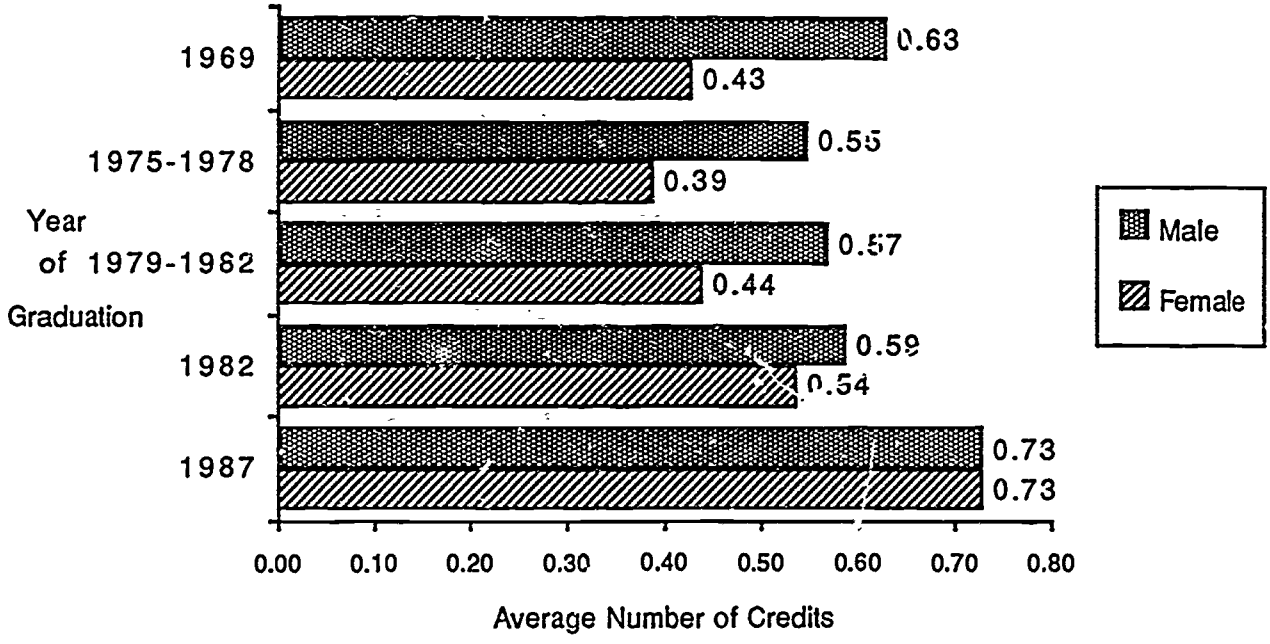
In 1987 Asian and white students earned approximately the same number of algebra credits (0.71 and 0.69 credits, respectively). Both black and Hispanic students earned

significantly fewer credits (both groups earned 0.59 credits) than either Asian or white students, (Figure 16). Black students suffered a significant decline in credits earned between 1969 and 1982, dropping from 0.77 credits to 0.47.

Advanced math (other than calculus)

The advanced math curriculum is the primary area in which young women caught up with young men in math course taking over the years studied (Figure 17). Between 1969 and 1982, young men earned roughly similar numbers of credits, while at the same time young women systematically increased the number of credits they earned from 0.43 credits in 1969 to 0.54 credits in 1982. In 1987 young men and women earned the same number of credits (0.73) and both groups experienced a significant increase in credits earned between 1982 and 1987.

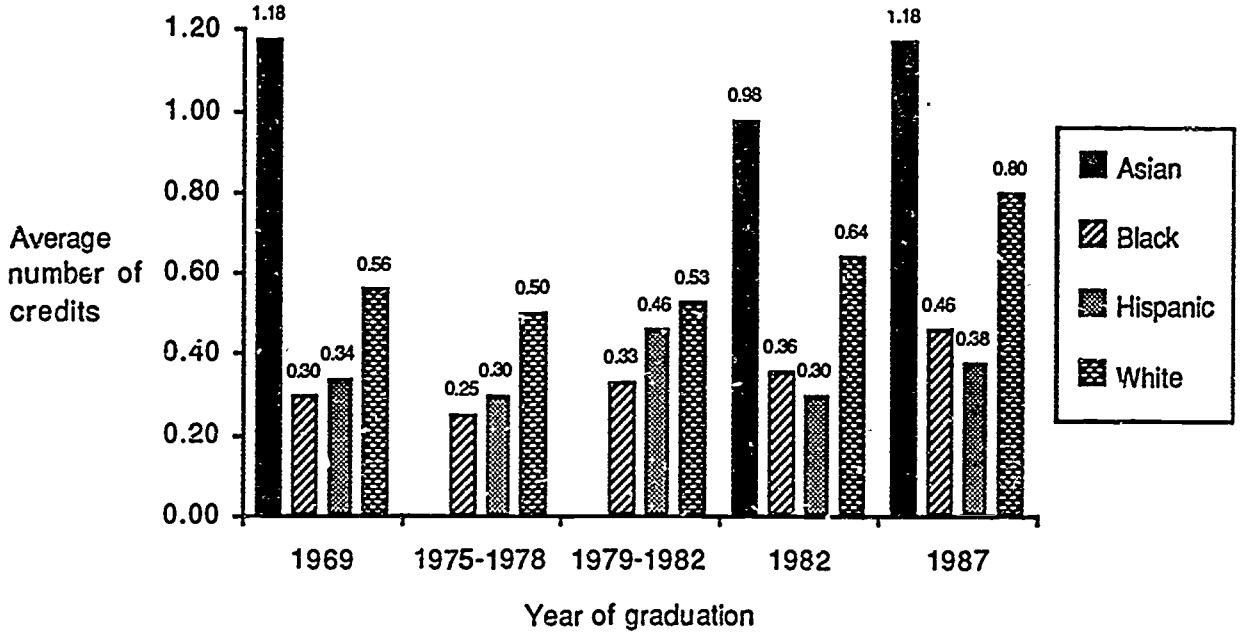
Figure 17 -- Average number of credits earned in advanced math



Asian students dominated advanced math course taking over the years studied. However, they varied little in the number of credits earned. For example, in 1987 Asians earned the same number of credits as in 1969 (1.18 credits), after a decline in credits earned in 1982 (0.98 credits). By contrast, black, Hispanic, and white students all earned more

credits in 1987 (0.46, 0.38, 0.80 credits, respectively) than in 1969, though still far fewer credits than Asian students.

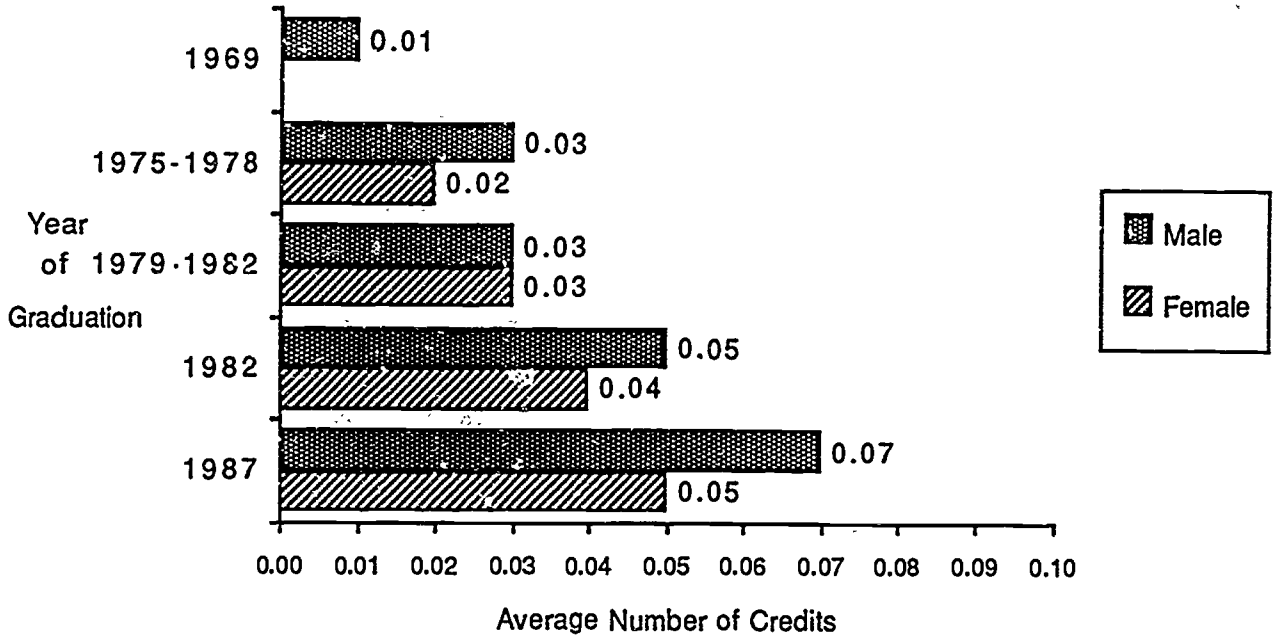
Figure 18 -- Average number of credits earned in advanced math



Calculus

Calculus is a subject that few high school students take. With the exception of Asian students, less than one-tenth of a credit was earned by any group over the years in study. However, it did appear that there was a small but consistent increase in participation. For example, the number of credits earned by young women in 1969 was less than 0.01 credits but by 1987, they were earning 0.05 credits (Figure 19) . The same pattern was seen for young men (0.01 credits in 1969 to 0.07 in 1987). The difference between the number of credits earned by young men and women was not statistically significant in any one cohort studied.

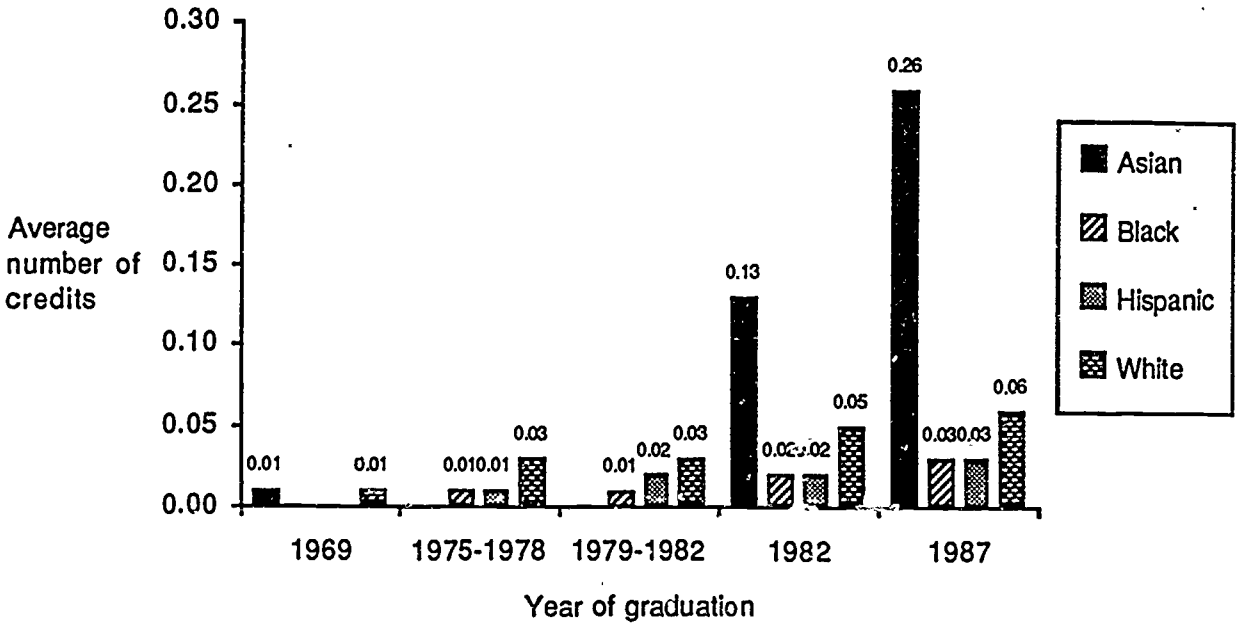
Figure 19 -- Average number of credits earned in calculus*



*Young women earned <0.01 credits in 1969

As was the case with advanced math other than calculus, Asian students earned by far, the most credits in calculus. In addition, between 1982 and 1987, Asian students approximately doubled the number of credits they earned from 0.13 to 0.26 credits, four times the number of credits earned by white students in 1987 (0.06 credits), and more than eight times the number of credits earned by black or Hispanic students (0.03 credits). Black, Hispanic, and white students also increased the number of credits they earned between 1982 and 1987, but to a much smaller extent than Asian students (Figure 20).

Figure 20 -- Average number of credits earned in calculus*



*Black and Hispanic students earned <0.01 credits in 1969

Science

The science curriculum was divided into four categories that generally reflected both subject matter and the complexity of the courses. These categories included science survey, biological sciences, chemistry, and physics.[7] It was also possible to break courses down within each of the four categories into less advanced and more advanced levels, but for the purpose of this analysis, only the four main categories will be examined.

Science Survey

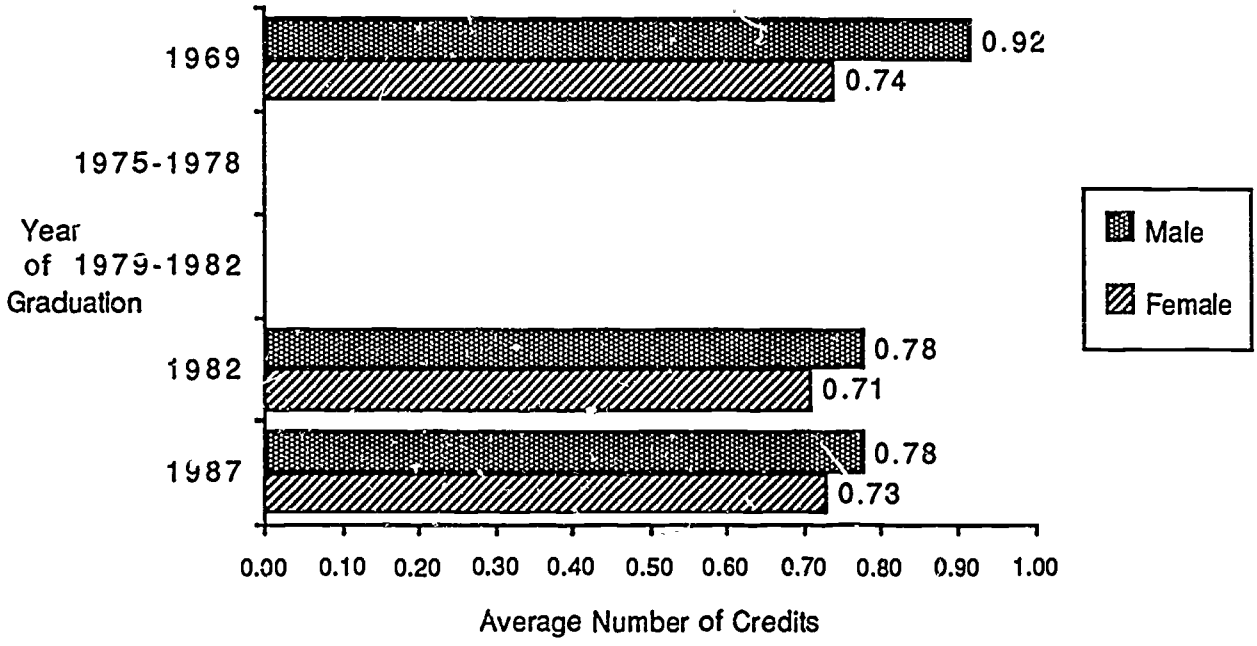
There were a wide range of courses falling into the science survey category ranging from eighth and ninth grade physical science to specialized topics such as mineralogy or

[7]A problem encountered with the NLSY cohorts in identifying courses was the classification of introductory physical science into the physics category. Consequently, in the NLSY cohort the number of credits earned in science survey is much less than the other cohorts and the number of credits earned in physics is much higher. Therefore, the NLSY samples were removed from the analysis when only science survey or physics were being examined.

cartography. In general, this category reflected both introductory and more general level courses.

Students took an average of one semester to one and one-half semesters in science survey. In 1969 young men earned approximately 20 percent more credits than young women: 0.92 credits compared to 0.74 credits (Figure 21). In 1982, however, the number of credits earned by young men in this subject dropped to 0.78 credits, while the number of credits earned by young women remained approximately the same. Unlike many other math and science subjects, the number of credits earned in science survey by either young men or women remained constant between 1982 and 1987.

Figure 21 -- Average number of credits earned in science survey*

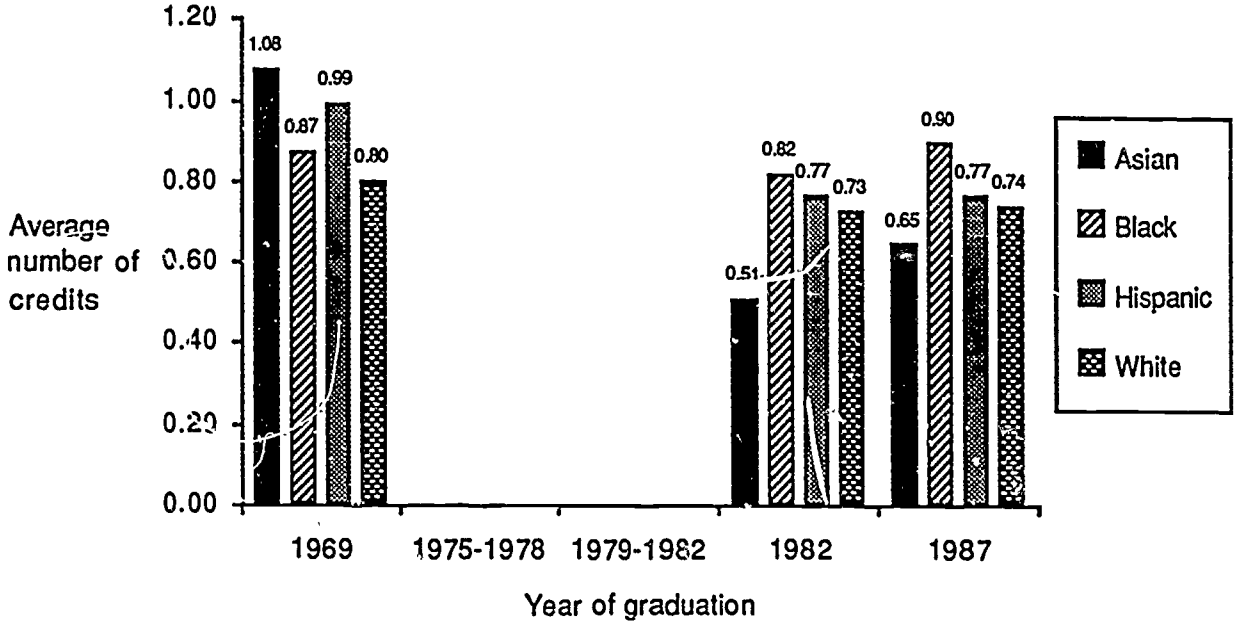


* NLSY cohort was not included due to misclassification of introductory physical science, a science survey course, as physics.

The greatest change in the number of credits earned in science survey over the years studied was experienced by Asian students, who earned less than half the credits in 1982 (0.51) as they earned in 1969 (1.08 credits). Asian students went from earning the most credits in 1969 to the fewest in both 1982 and 1987 (Figure 22). Hispanic students also experienced a significant drop in the number of credits earned between 1969 and 1982, dropping from 0.99 credits to 0.77 credits. In 1987 black students earned more credits in science survey courses than Asian, white, or Hispanic students. Between 1982 and 1987,

black students and Asian students increased the number of credits they earned while the number of credits earned by Hispanic and white students remained constant.

Figure 22 -- Average number of science survey credits earned*

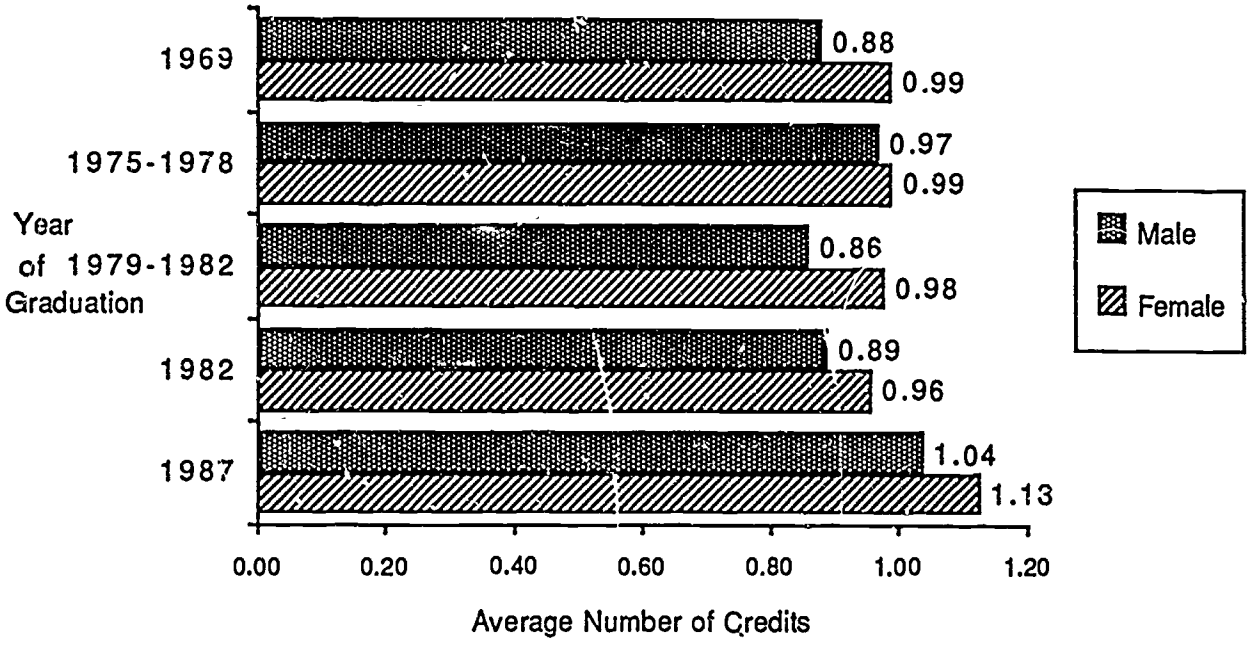


* NLSY cohort was not included due to misclassification of introductory physical science, a science survey course, as physics.

Biological sciences

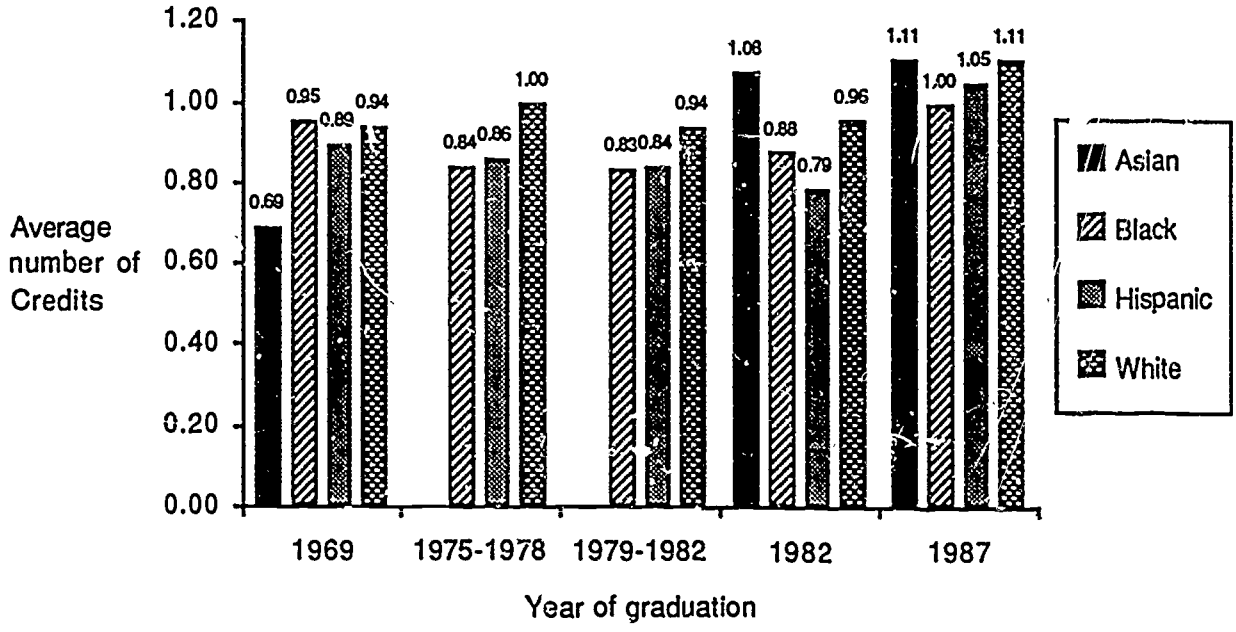
Students generally earned more science credits in the biological sciences than any other subject. In addition it is the only area in either the math or science curriculum where young women consistently earned more credits than young men (Figure 23). Both young men and women experienced a significant increase in the number of credits earned in the biological sciences between 1982 and 1987.

Figure 23 -- Average number of biological science credits earned



In 1969 black, Hispanic and white students earned roughly similar numbers of credits in biology, while Asian students earned significantly fewer credits (Figure 24). In 1982, however, the number of credits earned by Asian students nearly doubled and in this year Asian students earned the most credits. In 1987 the differences among all racial/ethnic groups diminished with roughly similar numbers of credits earned by all groups: 1.11 credits earned by Asian and white students, 1.05 credits earned by Hispanic students, and 1.0 credits earned by black students.

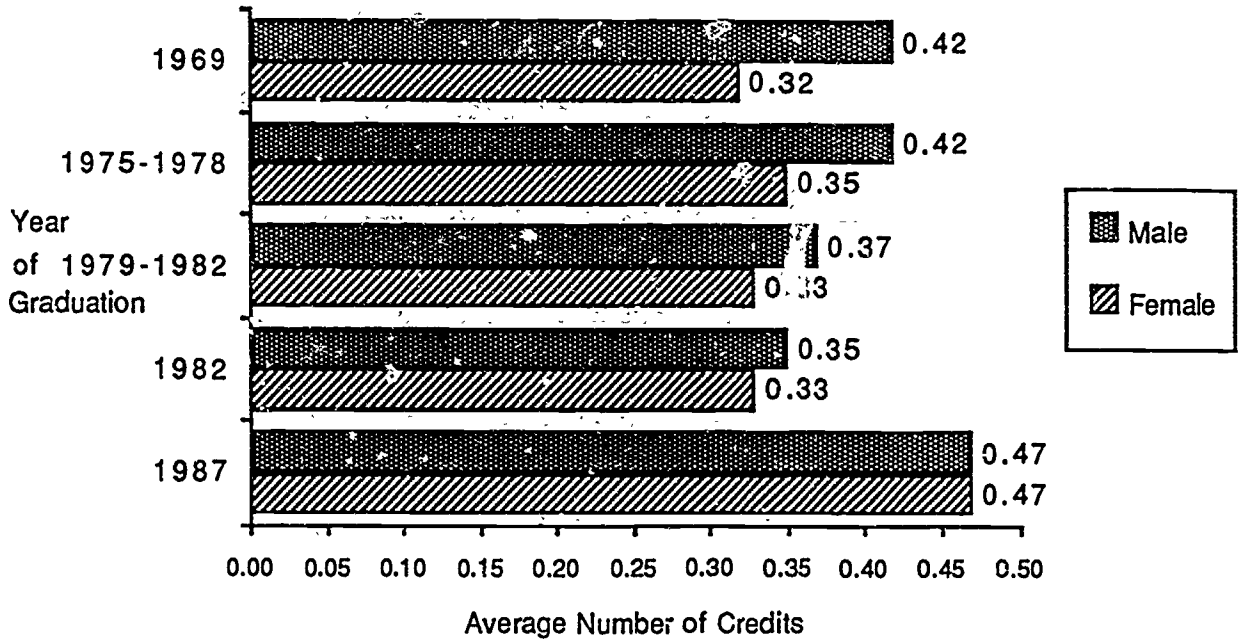
Figure 24 -- Average number of biological science credits earned



Chemistry

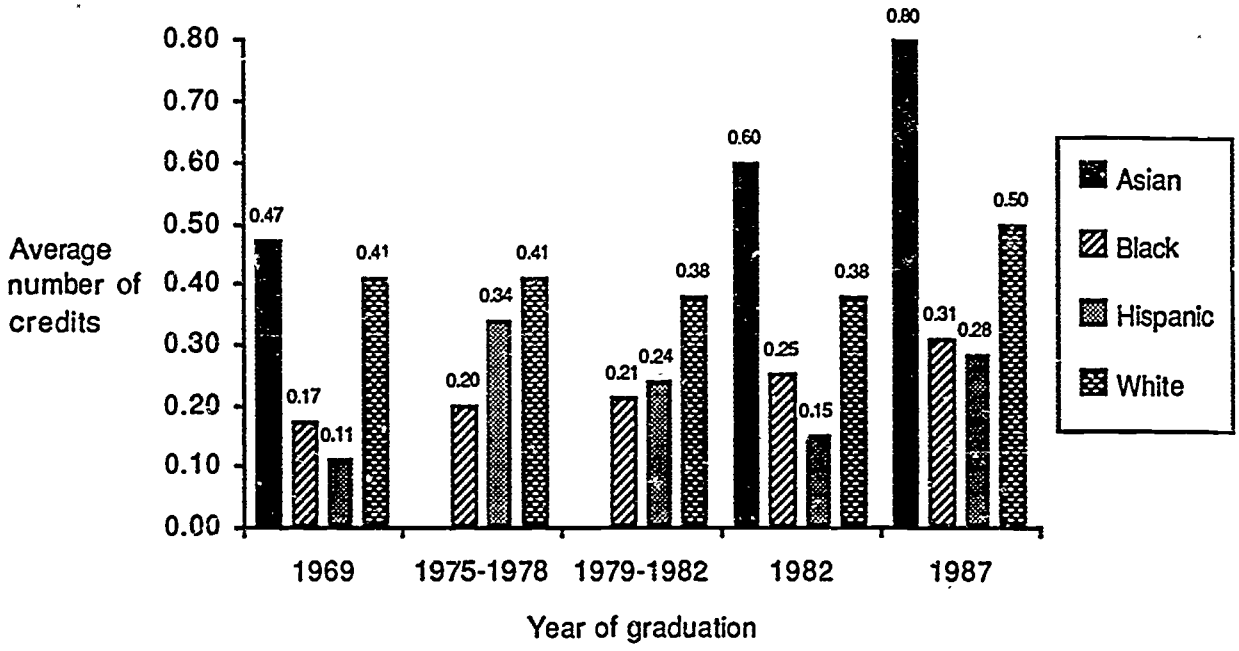
Overall there was very little change in the number of credits earned in chemistry between 1969 and 1982. Between 1982 and 1987, however, all students experienced an increase in the number of credits earned, regardless of gender or race/ethnicity. As was the case with science survey courses, young men experienced a decline in the number of credits earned between 1969 and 1982 (dropping from 0.42 to 0.35 credits) while the number of credits earned by young women remained relatively constant (Figure 25). In 1987, young men and women earned the same number of credits--the equivalent of approximately one semester (0.47 credits).

Figure 25 -- Average number of credits earned in chemistry



Among racial/ethnic groups, however, great differences in participation in chemistry courses persisted throughout all cohorts. Asian students demonstrated the greatest increase in credits earned over the years studied (0.47 credits in 1969, 0.6 credits in 1982, and 0.8 credits in 1987). In addition they earned more credits than the remaining racial/ethnic groups. White students generally earned more credits than either Hispanic or black students in all cohorts. Black students experienced a small but consistent increase in credits earned, from a low of 0.17 credits in 1969 to 0.31 credits in 1987. Hispanic students showed more fluctuation over the years but they more than doubled the number of credits earned between 1969 and 1987--an increase from 0.11 credits in 1969 to 0.28 credits in 1987.

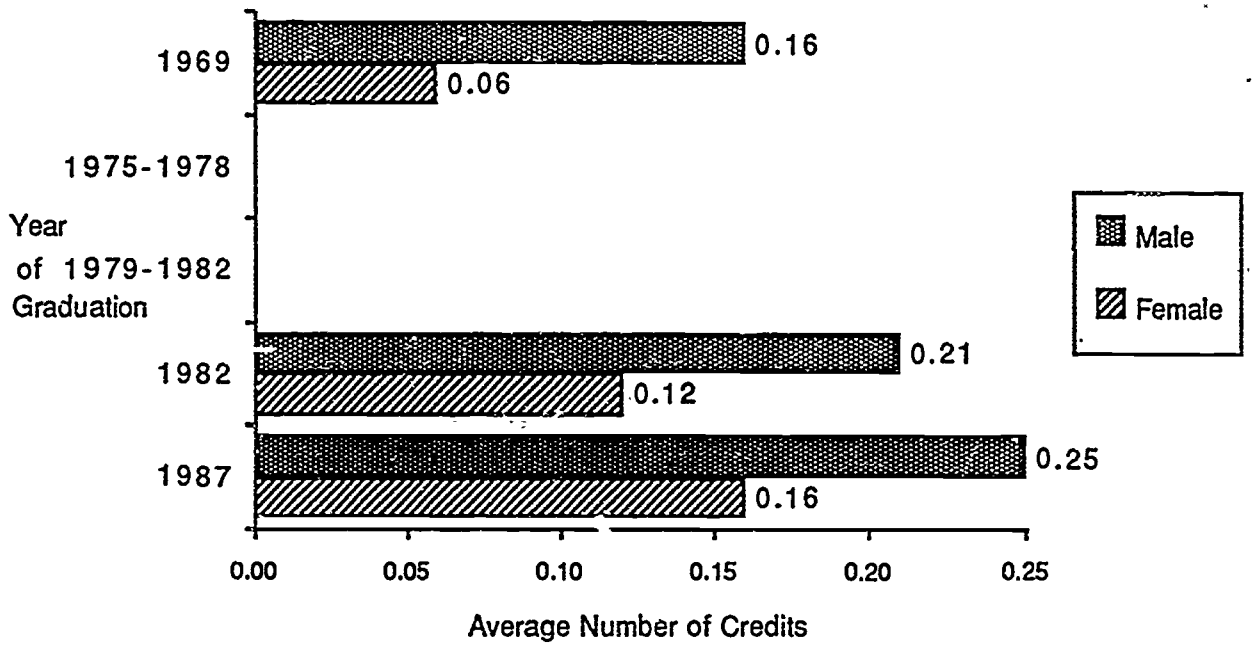
Figure 26 -- Average number of credits earned in chemistry



Physics

Even though few physics credits were earned in any of the cohorts, this subject remains the great divider between young men and women and also among the different racial/ethnic groups. Both young men and women experienced a small but consistent increase in the number of credits earned between 1969 and 1987. However, young men consistently earned 40 to 50 percent more physics credits than young women (Figure 27).

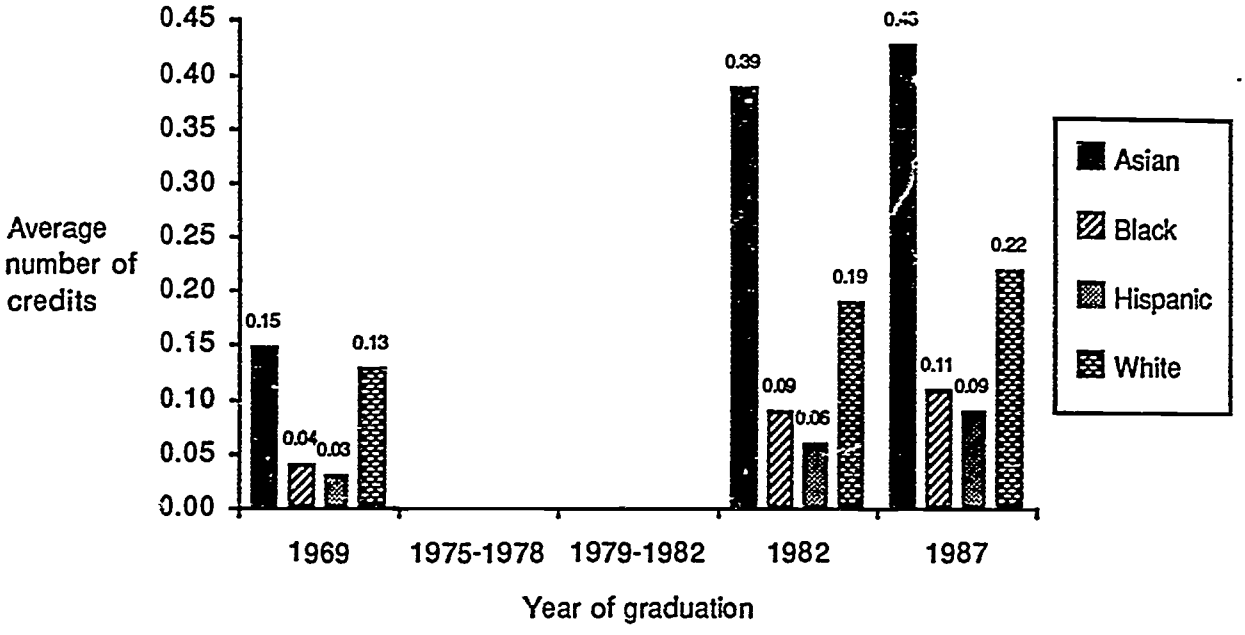
Figure 27 -- Average number of credits earned in physics*



* NLSY cohort was not included due to misclassification of introductory physical science, a science survey course, as physics.

All racial/ethnic groups experienced consistent increases in the number of credits earned in physics. However, as was observed for calculus, in 1982 and 1987 Asian students earned far more credits in physics than white, Hispanic, or black students. Between 1969 and 1982, the number of credits earned by Asian students more than doubled from 0.15 to 0.39 credits. While other groups also experienced increases, they were much smaller. In 1987 Asian students earned twice the number of credits in physics as white students. In turn, white students earned twice the number of credits as either black or Hispanic students.

Figure 28 -- Average number of credits earned in physics*



* NLSY cohort was not included due to miss-classification of introductory physical science, a science survey course, as physics.

Discussion

It is clear from this study that high school graduates are completing more math and science courses during their high school years. This change is most striking between 1982 and 1987, possibly reflecting recent reforms in high school education requirements (see also Kolstad and Thorne, 1989).

Young women have appeared to narrow the gender gap in math and science course taking in most subjects. For example, in advanced math courses other than calculus, young women completed the same number of credits as young men, increasing the number of credits earned in these subjects by more than 50 percent between 1969 and 1987. However, young women still tend to lag behind young men in the most advanced math and science courses such as calculus and physics.

While it is encouraging to see overall increases in math and science course taking, significant differences in the level and complexity of courses taken still remain among the

various racial/ethnic groups. Asian students consistently completed more credits in the most advanced subjects, for example calculus and physics, while taking the fewest number of credits in the more basic courses such as general math and science survey. On the other hand, black and Hispanic students generally exhibited the opposite trend, that is, taking the fewest advanced level courses and the most basic level courses. If taking more advanced math and science courses in high school is an important preparation for gaining entrance into the growing fields of science and technology, then more effort to involve students traditionally underrepresented in these fields must be made before and during high school.

Finally, it is important to remember that this study provides only a general measure of the number of courses completed in high school math and science without taking into account changes in achievement or changes in the quality of education. There is no way to tell from the data whether current courses have become shorter or changed in scope since reforms were enacted. Future research is needed that connects course taking to achievement to evaluate the effect of the trends illustrated in this paper.

References

Clearinghouse Notes, *Education Commission of the States,* Denver, Colorado, September, 1987.

Hoachlander, E.G., Brown, C. and J. Tuma, *Measuring High School Curricular Experiences: Implications for Vocational Education,* a report prepared for the National Assessment of Vocational Education, U.S. Department of Education, December, 1987.

Kolstad, A. and J. Thorne, *Changes in High School Course Work from 1982 to 1987: evidence from two national surveys,* a paper prepared for presentation to the annual meetings of the AERA, March 27, 1989.

National Science Board, *Science and Education Indicators - 1987,* U.S. Government Printing Office, Washington, D.C. 20402, Stock Number 038-000-00578-2, p 9.

Task Force on Women, Minorities, and the Handicapped in Science and Technology, *Changing America: The New Face of Science and Engineering,* Final Report, December, 1989, p 3.

Tuma, J., Gifford, A., Horn, L. and E.G. Hoachlander, *Enrollment Trends in Vocational and Academic Education in American Public High Schools,* 1969 to 1987, A report prepared for the National Assessment of Vocational Education, U.S. Department of Education, April 1988, pp 82-95.